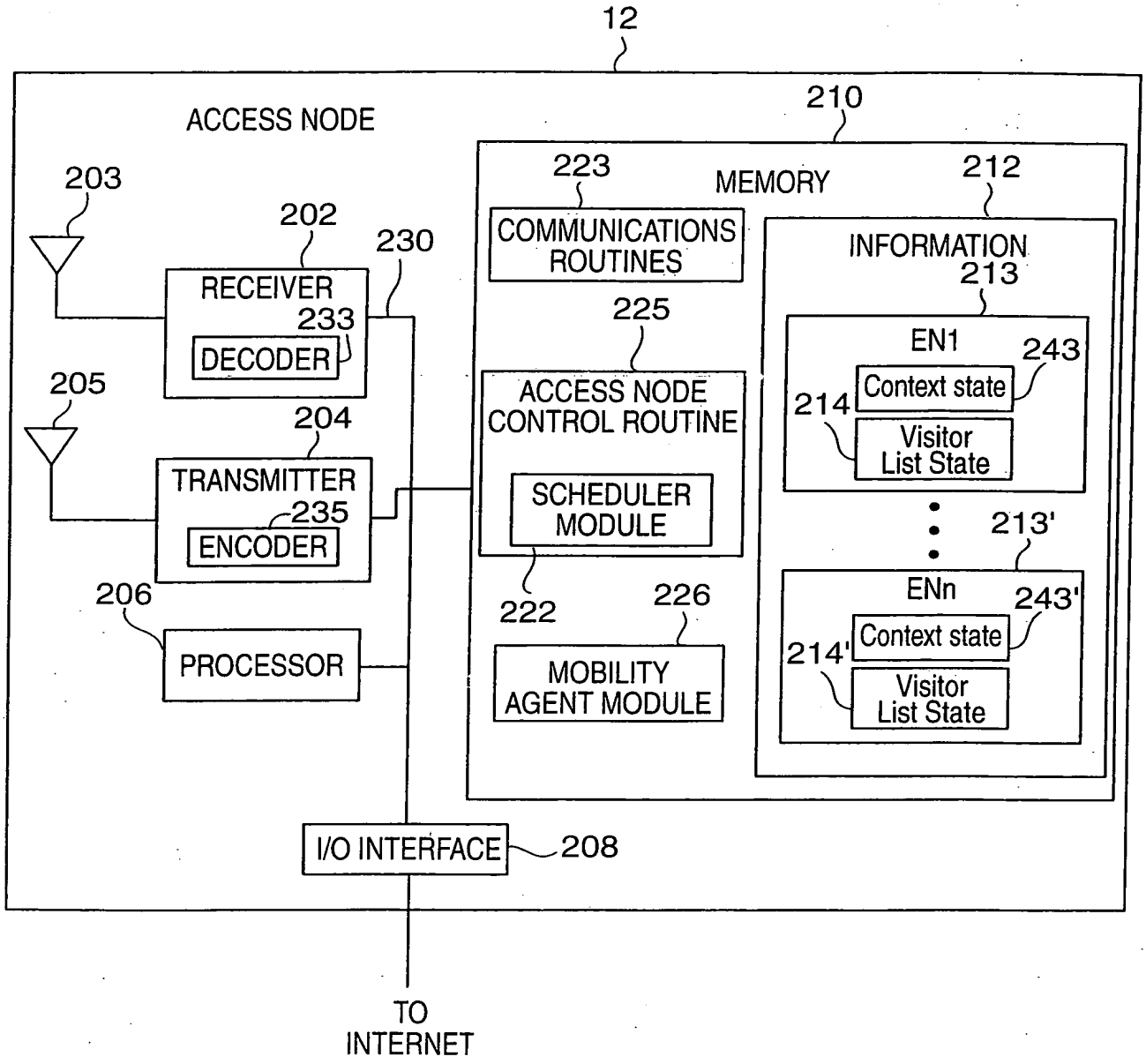

12
ACCESS NODE
210
203
223
MEMORY
212
202
230
COMMUNICATIONS ROUTINES
INFORMATION
213
RECEIVER
233
DECODER
225
EN1
243
205
ACCESS NODE CONTROL ROUTINE
214
Context state
204
Visitor List State
TRANSMITTER
235
ENCODER
SCHEDULER MODULE
213'
206
ENn
243'
222
226
214'
Context state
PROCESSOR
MOBILITY AGENT MODULE
Visitor List State
I/O INTERFACE
208
TO INTERNET

FIG. 1

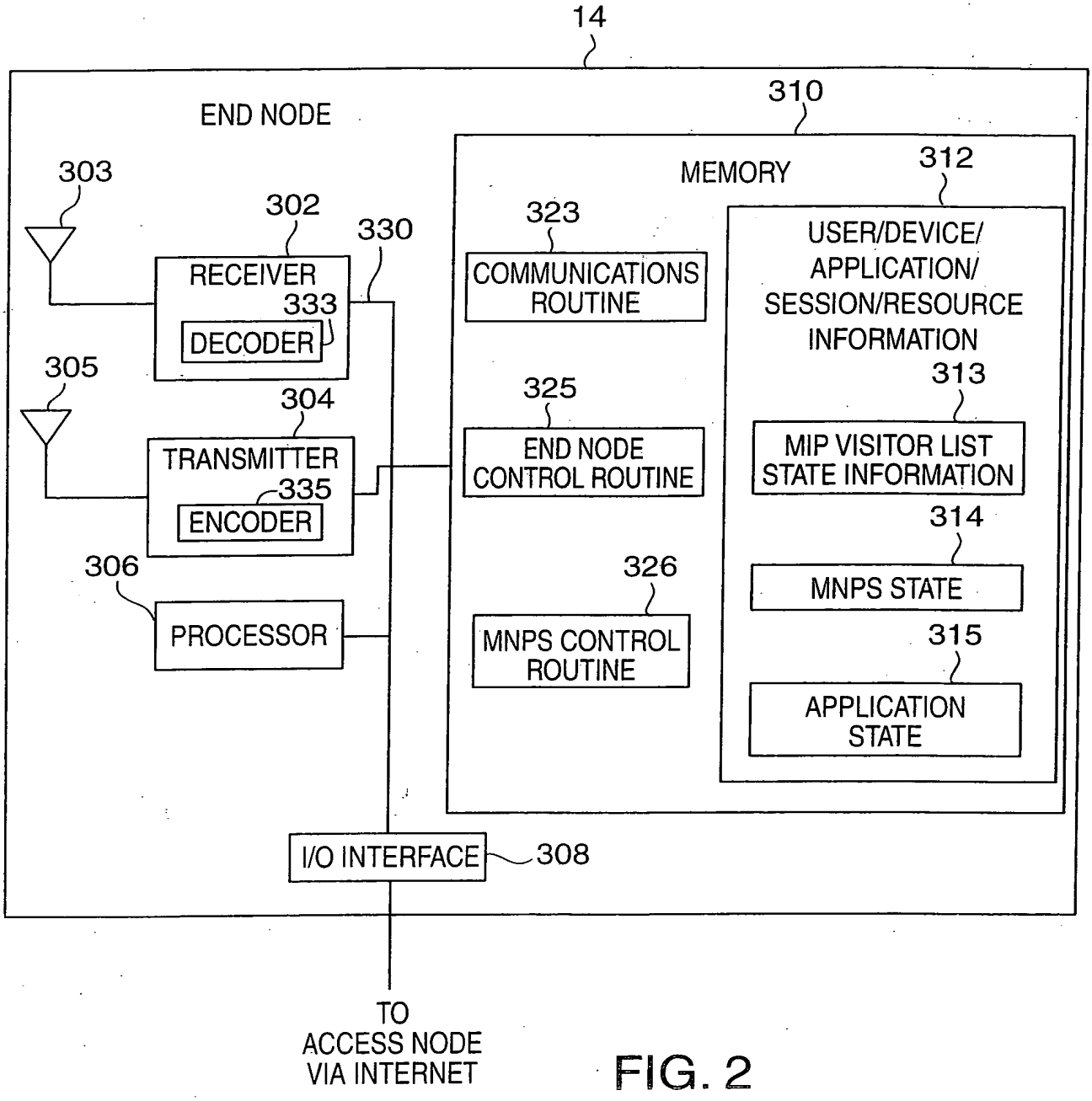

14
END NODE
310
MEMORY
312
303
302
330
323
RECEIVER
333
DECODER
COMMUNICATIONS ROUTINE
USER/DEVICE/ APPLICATION/ SESSION/RESOURCE INFORMATION
305
304
325
313
TRANSMITTER
335
ENCODER
END NODE CONTROL ROUTINE
MIP VISITOR LIST STATE INFORMATION
314
306
326
MNPS STATE
PROCESSOR
MNPS CONTROL ROUTINE
315
APPLICATION STATE
I/O INTERFACE
308
TO ACCESS NODE VIA INTERNET

FIG. 2

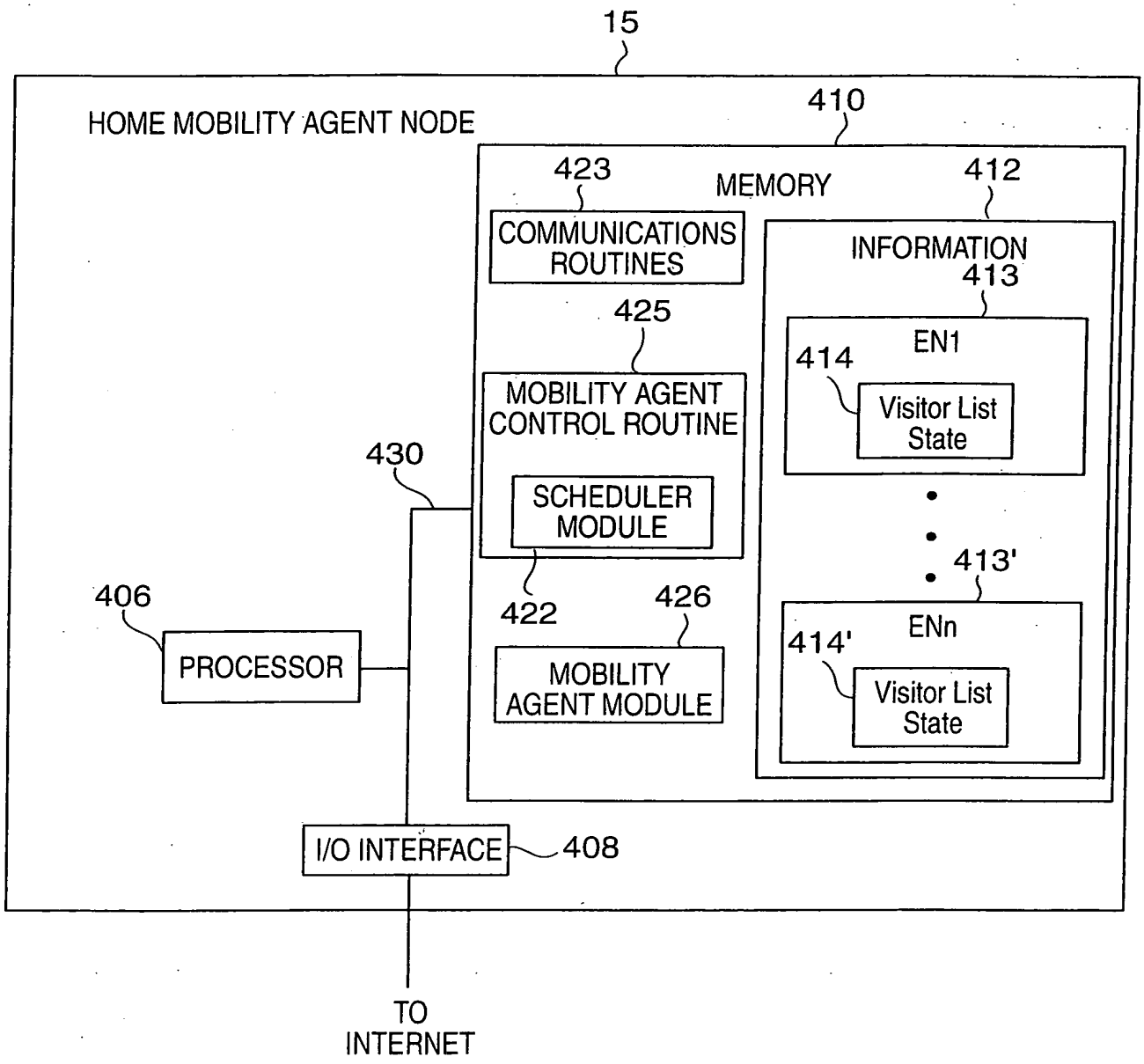

15
HOME MOBILITY AGENT NODE
410
423
MEMORY
412
COMMUNICATIONS ROUTINES
INFORMATION
413
425
EN1
414
MOBILITY AGENT CONTROL ROUTINE
Visitor List State
430
SCHEDULER MODULE
413'
406
422
426
ENn
414'
PROCESSOR
MOBILITY AGENT MODULE
Visitor List State
I/O INTERFACE
408
TO INTERNET

FIG. 3

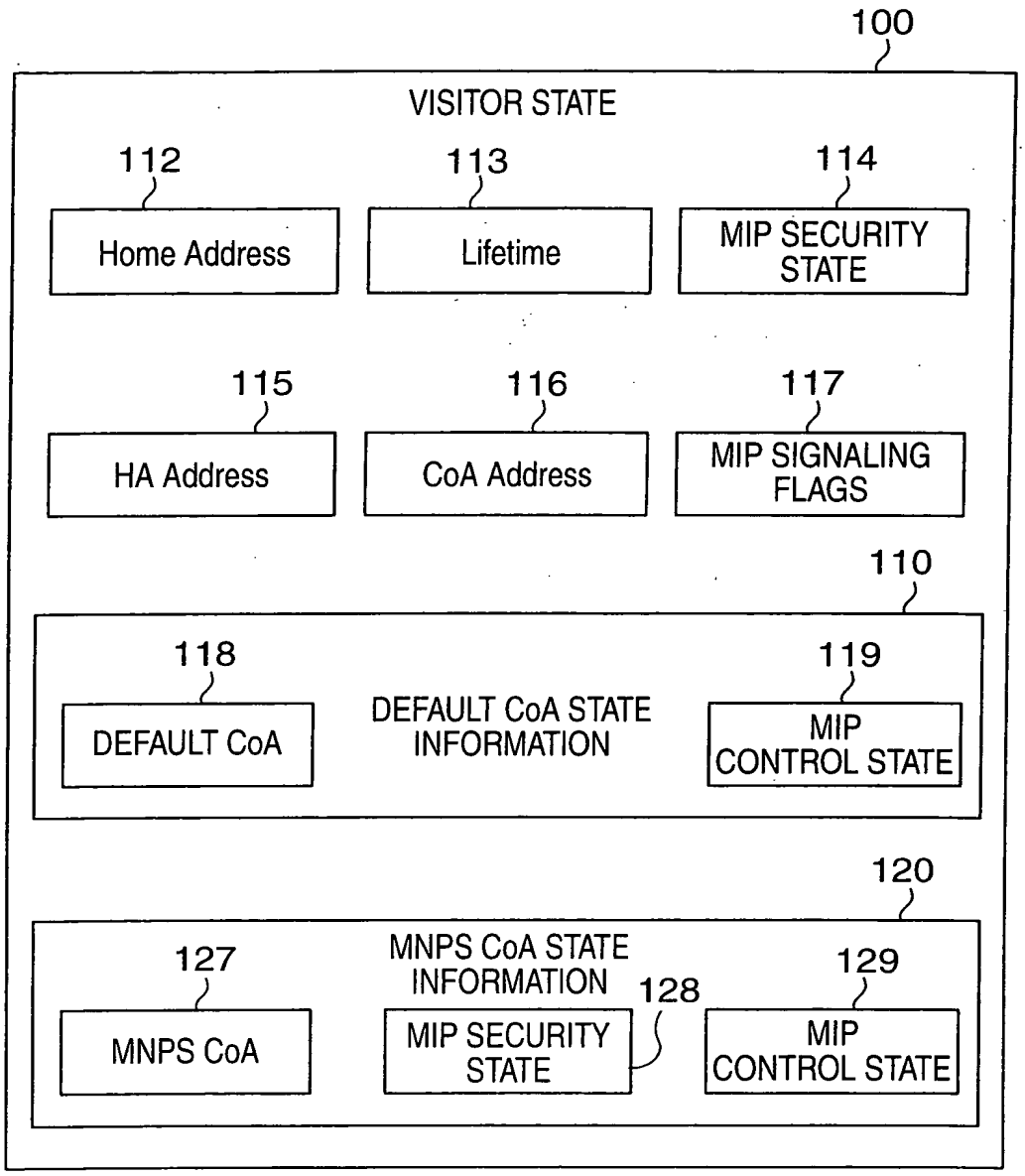

100
VISITOR STATE
112
Home Address
113
Lifetime
114
MIP SECURITY STATE
115
HA Address
116
CoA Address
117
MIP SIGNALING FLAGS
110
118
DEFAULT CoA
DEFAULT CoA STATE INFORMATION
119
MIP CONTROL STATE
120
127
MNPS CoA
MNPS CoA STATE INFORMATION
128
MIP SECURITY STATE
129
MIP CONTROL STATE

FIG. 4

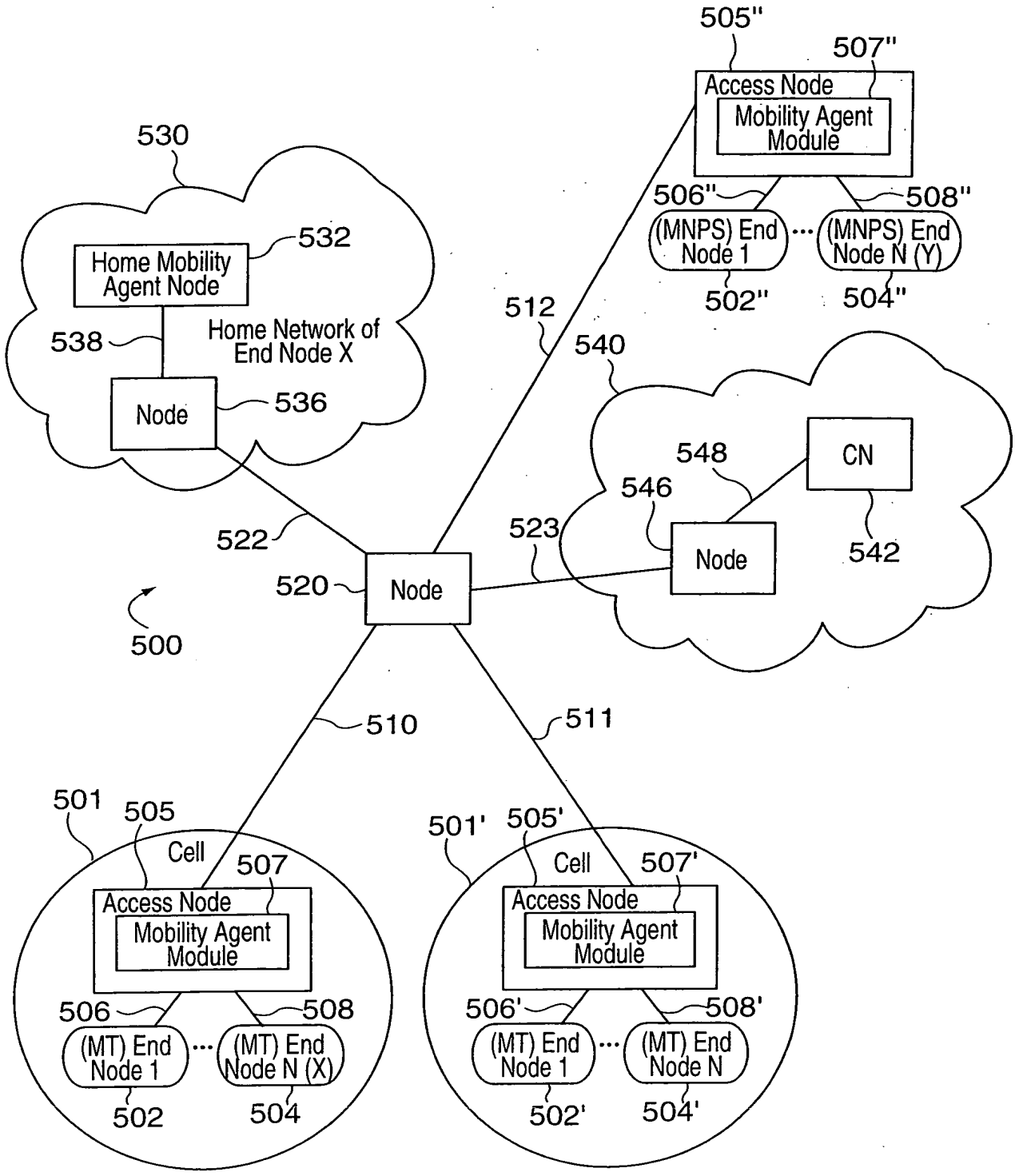

505"
507"
Access Node
Mobility Agent Module
530
506"
508"
(MNPS) End Node 1
(MNPS) End Node N (Y)
502"
504"
532
Home Mobility Agent Node
512
538
Home Network of End Node X
540
Node
536
548
CN
546
523
Node
542
522
520
Node
500
510
511
501
505
Cell
507
Access Node
Mobility Agent Module
506
508
(MT) End Node 1
(MT) End Node N (X)
502
504
501'
505'
Cell
507'
Access Node
Mobility Agent Module
506'
508'
(MT) End Node 1
(MT) End Node N
502'
504'

FIG. 5

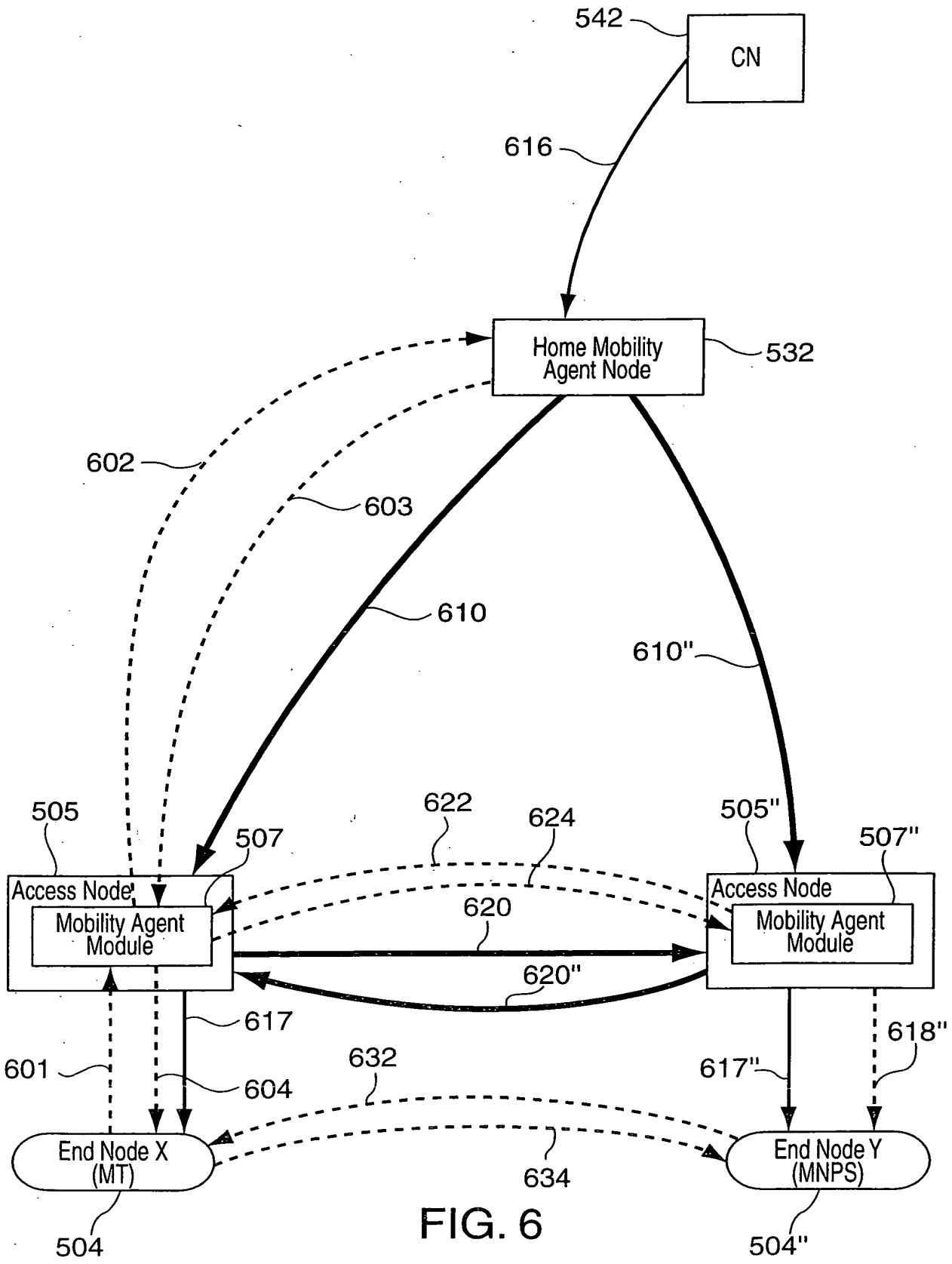

542
CN
616
Home Mobility Agent Node
532
602
603
610
610"
505
507
622
624
505"
507"
Access Node
Mobility Agent Module
620
620"
Access Node
Mobility Agent Module
617
618"
601
604
632
617"
End Node X (MT)
634
End Node Y (MNPS)
504
504"

FIG. 6

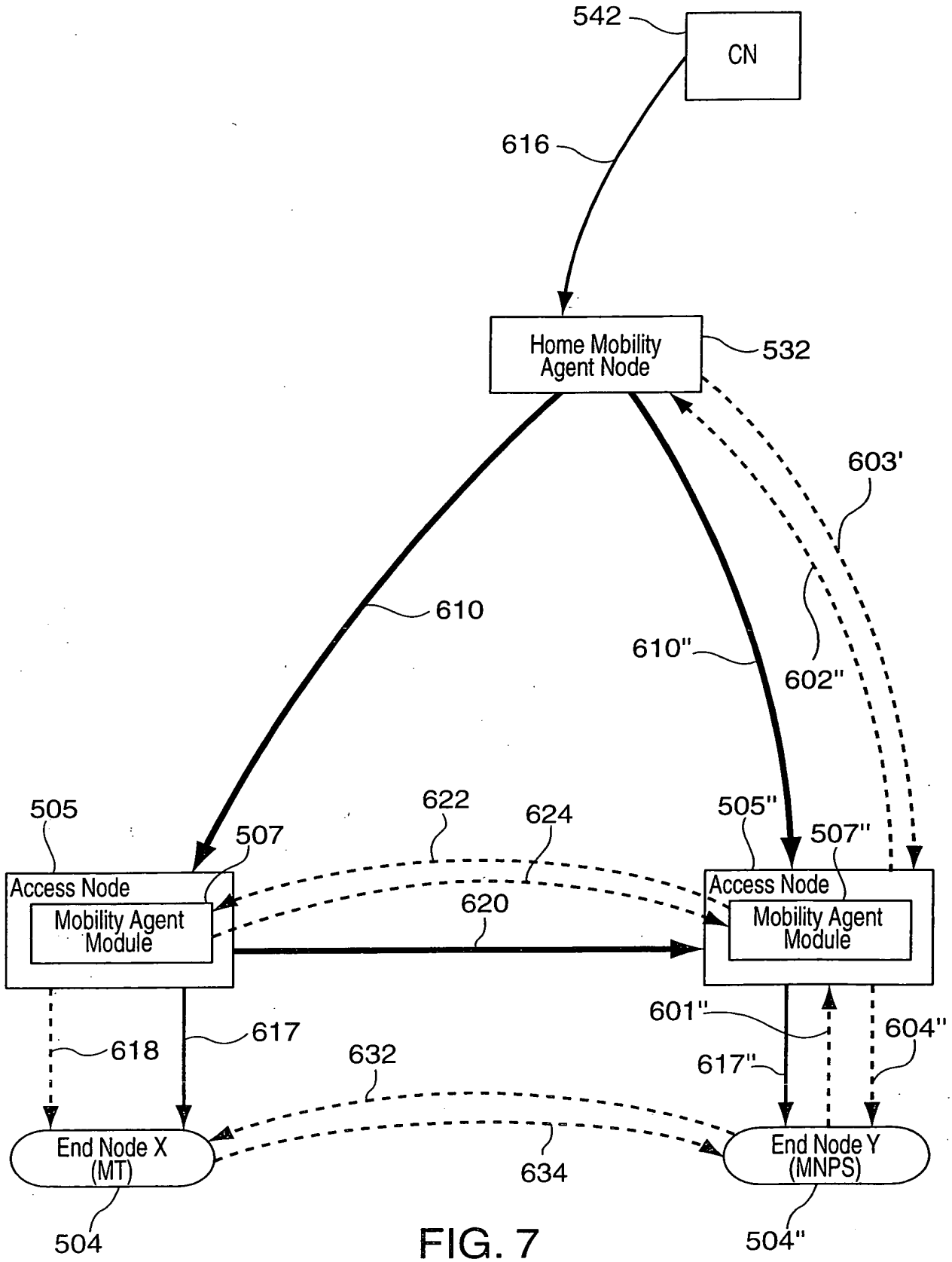

542
CN
616
Home Mobility Agent Node
532
603'
610
610"
602"
505
622
624
505"
507
507"
Access Node
Mobility Agent Module
620
Access Node
Mobility Agent Module
601"
604"
618
617
632
617"
End Node X (MT)
634
End Node Y (MNPS)
504
504"

FIG. 7

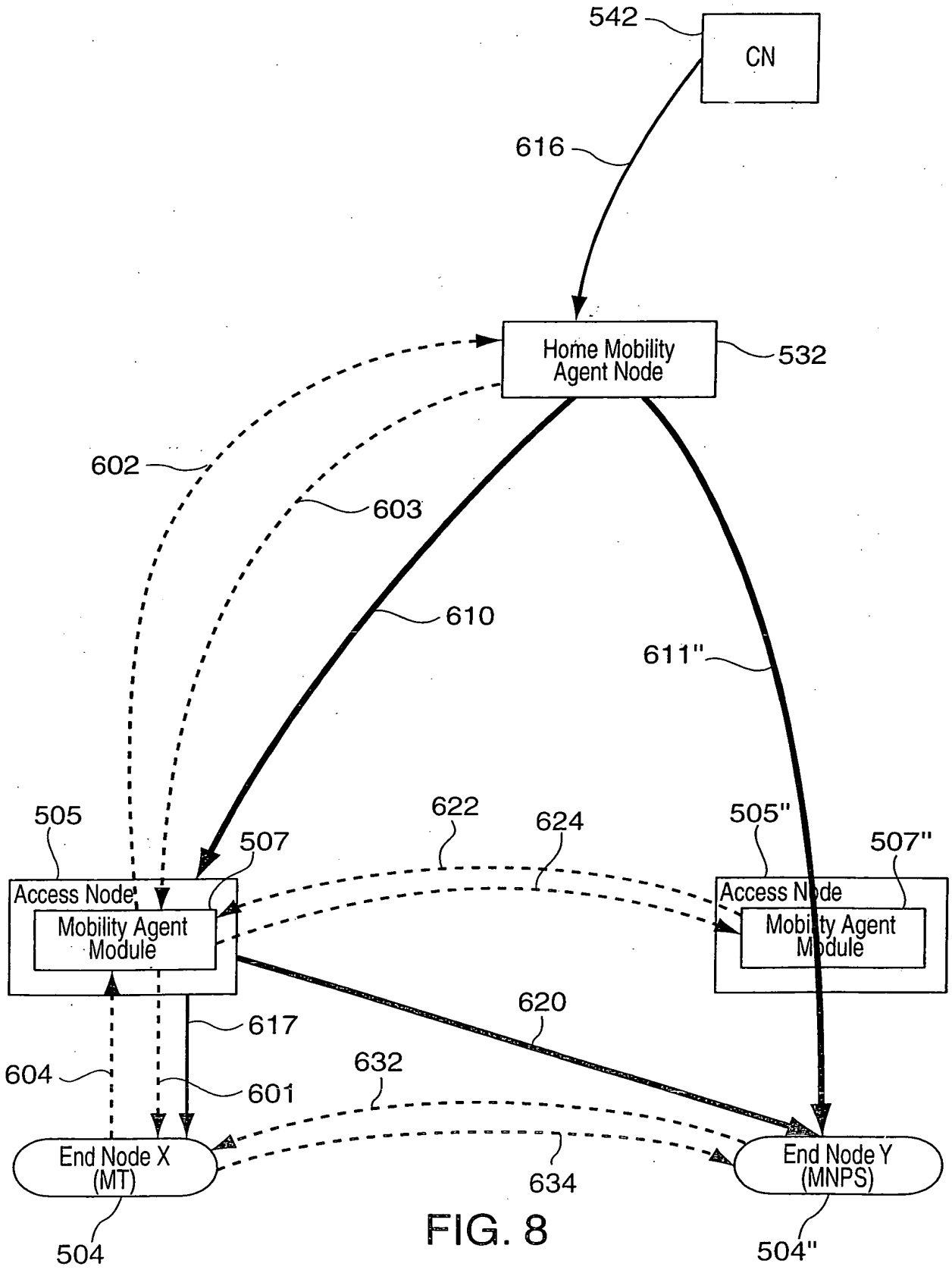

542
CN
616
Home Mobility Agent Node
532
602
603
610
611"
505
507
622
624
505"
507"
Access Node
Mobility Agent Module
Access Node
Mobility Agent Module
620
617
604
632
601
End Node X (MT)
634
End Node Y (MNPS)
504
504"

FIG. 8

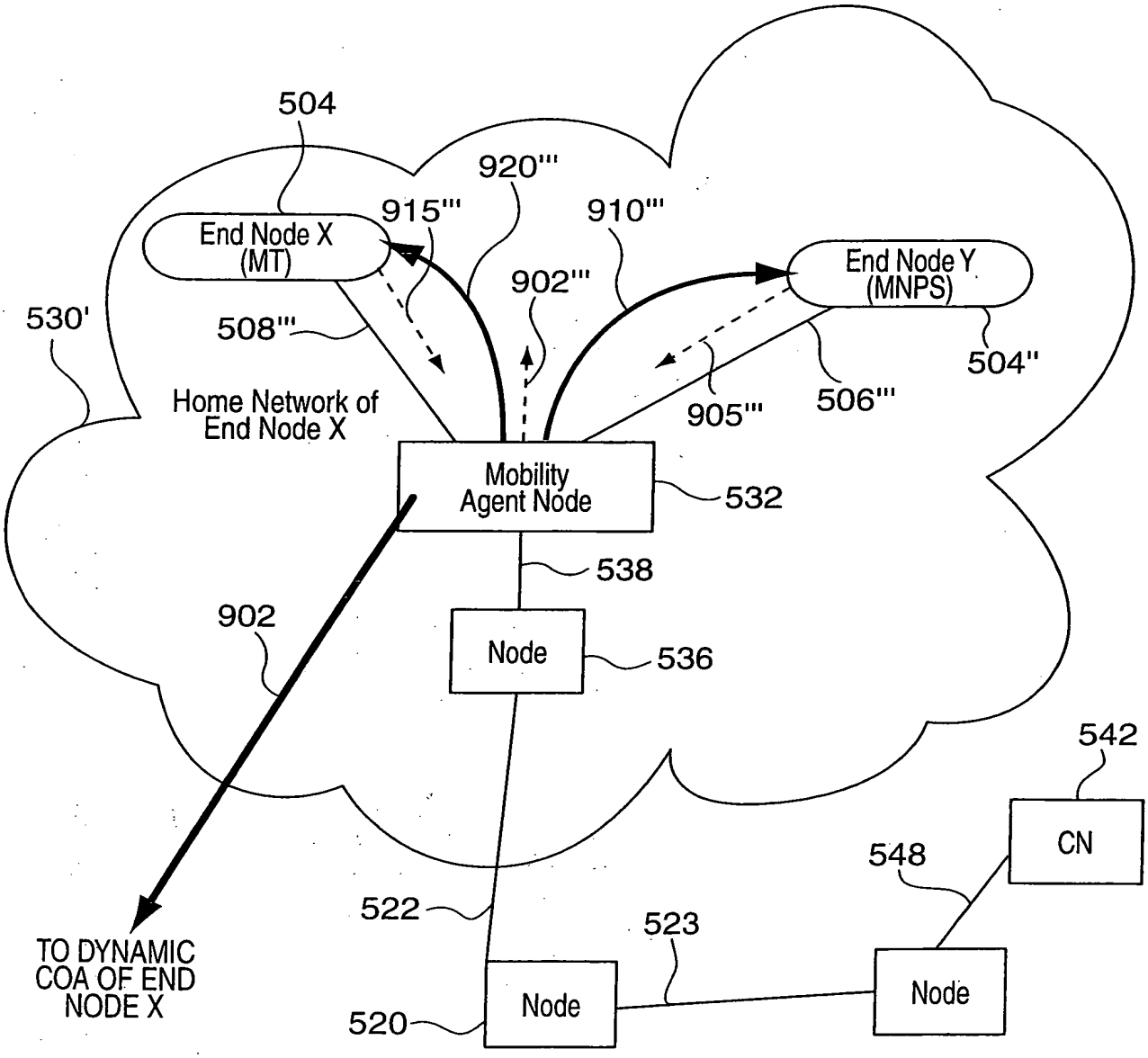

504
920'''
915'''
910'''
End Node X
(MT)
End Node Y
(MNPS)
902'''
530'
508'''
504''
Home Network of
End Node X
905'''
506'''
Mobility
Agent Node
532
538
902
Node
536
542
CN
548
522
523
TO DYNAMIC
COA OF END
NODE X
Node
Node
520

FIG. 9

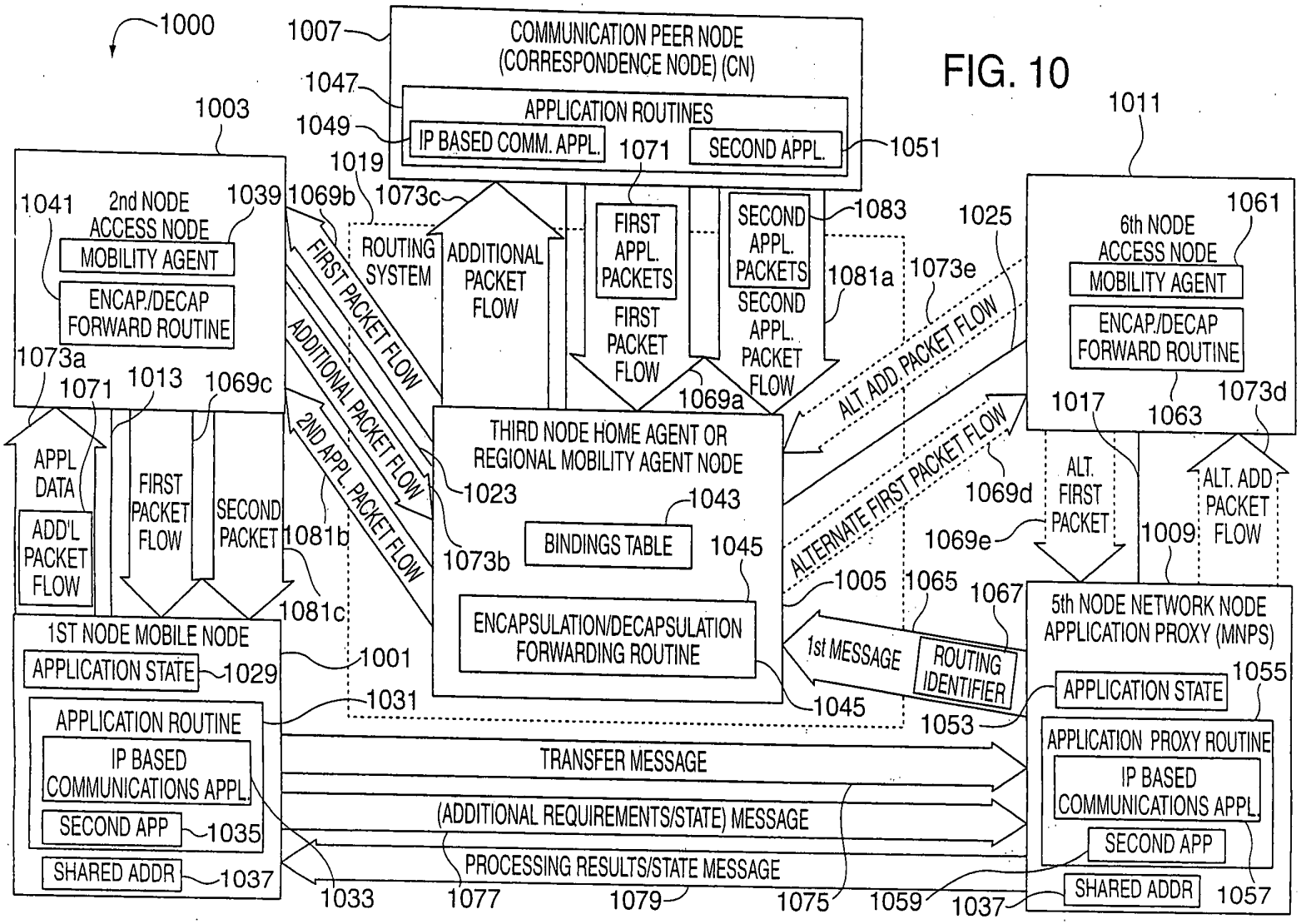

1000
1007
COMMUNICATION PEER NODE (CORRESPONDENCE NODE) (CN)
1047
APPLICATION ROUTINES
1049
IP BASED COMM. APPL.
1071
SECOND APPL.
1051
1019
1003
1011
1041
2nd NODE ACCESS NODE
1039
1069b
1073c
MOBILITY AGENT
ENCAP./DECAP FORWARD ROUTINE
ROUTING SYSTEM
ADDITIONAL PACKET FLOW
FIRST APPL. PACKETS
SECOND APPL. PACKETS
1083
1025
1061
6th NODE ACCESS NODE
MOBILITY AGENT
ENCAP./DECAP FORWARD ROUTINE
1081a
1073e
FIRST PACKET FLOW
ADDITIONAL PACKET FLOW
2ND APPL. PACKET FLOW
FIRST PACKET FLOW
SECOND APPL. PACKET FLOW
1069a
ALT. ADD. PACKET FLOW
1073a
1071
1013
1069c
1017
1063
1073d
APPL DATA
ADD'L PACKET FLOW
FIRST PACKET FLOW
SECOND PACKET
1081b
THIRD NODE HOME AGENT OR REGIONAL MOBILITY AGENT NODE
1023
1043
BINDINGS TABLE
1045
1073b
1069d
ALTERNATE FIRST PACKET FLOW
ALT. FIRST PACKET
ALT. ADD PACKET FLOW
1069e
1009
1005
1065
1067
ENCAPSULATION/DECAPSULATION FORWARDING ROUTINE
1st MESSAGE
ROUTING IDENTIFIER
5th NODE NETWORK NODE APPLICATION PROXY (MNPS)
1081c
1001
1055
1053
1045
1031
1029
1ST NODE MOBILE NODE
APPLICATION STATE
APPLICATION ROUTINE
IP BASED COMMUNICATIONS APPL.
SECOND APP
1035
SHARED ADDR
1037
APPLICATION STATE
APPLICATION PROXY ROUTINE
IP BASED COMMUNICATIONS APPL.
SECOND APP
SHARED ADDR
1057
TRANSFER MESSAGE
(ADDITIONAL REQUIREMENTS/STATE) MESSAGE
PROCESSING RESULTS/STATE MESSAGE
1033
1077
1079
1075
1059
1037

FIG. 10

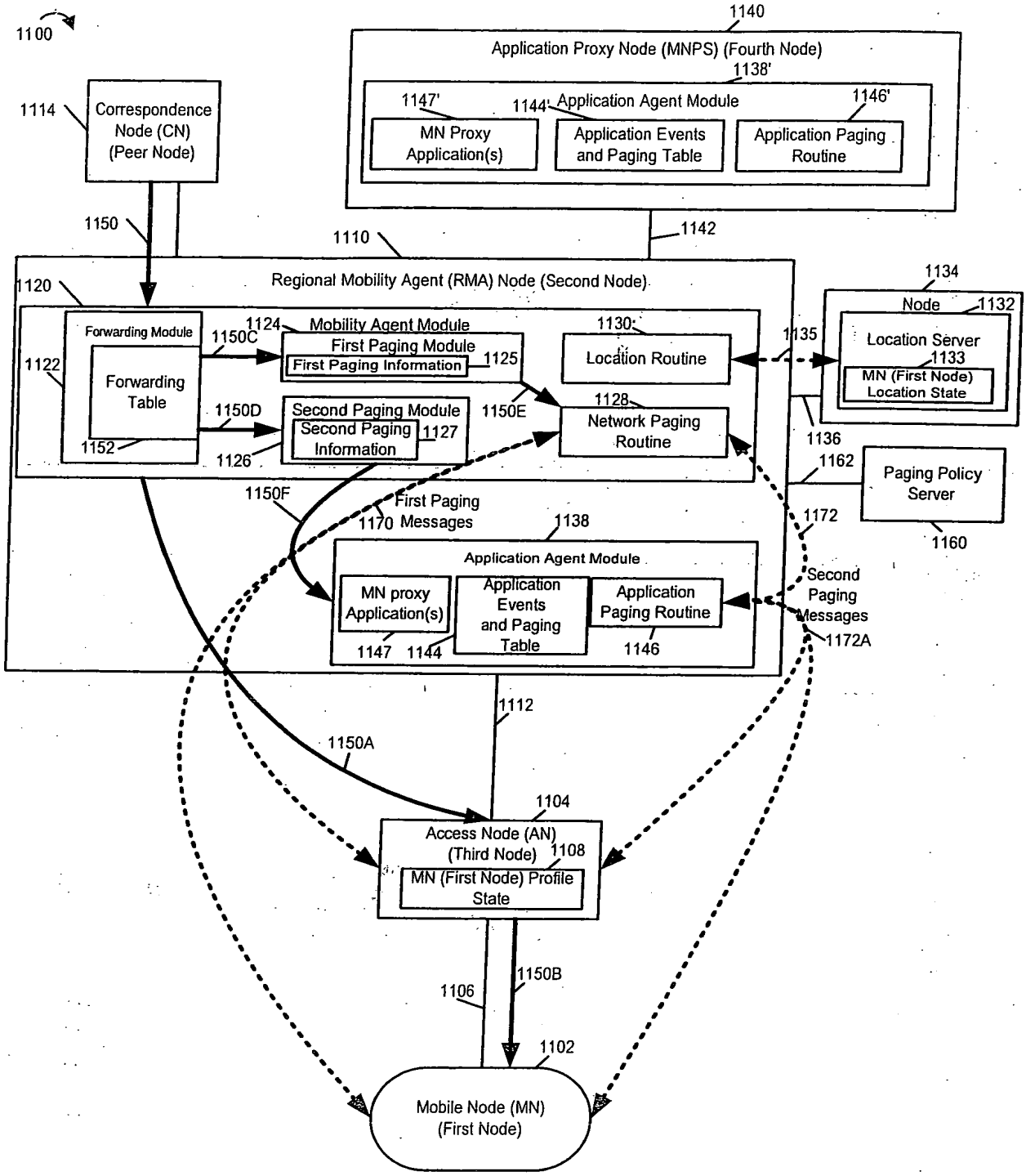

1100
1140
Application Proxy Node (MNPS) (Fourth Node)
1138'
1147'
1144'
Application Agent Module
1146'
MN Proxy Application(s)
Application Events and Paging Table
Application Paging Routine
1114
Correspondence Node (CN) (Peer Node)
1150
1110
1142
1120
Regional Mobility Agent (RMA) Node (Second Node)
1134
Node
1132
Forwarding Module
1124
Mobility Agent Module
1130
1135
Location Server
1133
1150C
First Paging Module
First Paging Information
1125
Location Routine
MN (First Node) Location State
1122
Forwarding Table
1150D
Second Paging Module
Second Paging Information
1127
1150E
1128
Network Paging Routine
1136
1152
1126
1162
Paging Policy Server
1150F
First Paging Messages
1170
1138
1172
1160
Application Agent Module
MN proxy Application(s)
Application Events and Paging Table
Application Paging Routine
Second Paging Messages
1172A
1147
1144
1146
1112
1150A
1104
Access Node (AN) (Third Node)
1108
MN (First Node) Profile State
1150B
1106
1102
Mobile Node (MN) (First Node)

Fig. 11

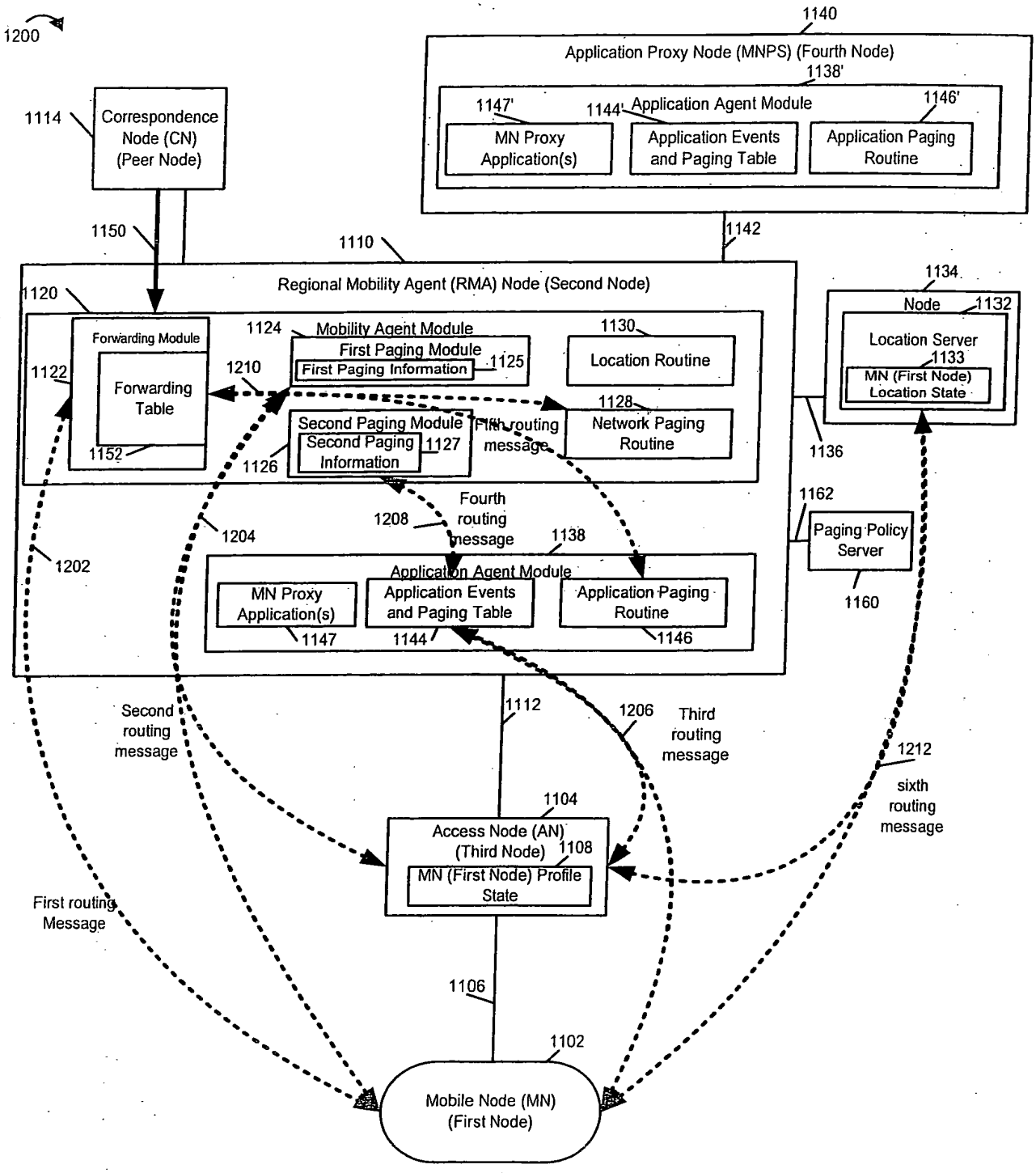

1200
1140
Application Proxy Node (MNPS) (Fourth Node)
1138'
1147'
1144'
Application Agent Module
1146'
MN Proxy Application(s)
Application Events and Paging Table
Application Paging Routine
1114
Correspondence Node (CN) (Peer Node)
1150
1110
1142
Regional Mobility Agent (RMA) Node (Second Node)
1120
1134
Node
1132
Location Server
1133
MN (First Node) Location State
Forwarding Module
1124
Mobility Agent Module
1130
First Paging Module
First Paging Information
1125
Location Routine
1122
Forwarding Table
1210
1128
Second Paging Module
Second Paging Information
1127
Fifth routing message
Network Paging Routine
1152
1126
1136
1162
Fourth routing message
1208
1204
1138
Paging Policy Server
1202
Application Agent Module
MN Proxy Application(s)
Application Events and Paging Table
Application Paging Routine
1147
1144
1146
1160
1112
1206
Third routing message
Second routing message
1212
sixth routing message
1104
Access Node (AN) (Third Node)
1108
MN (First Node) Profile State
First routing Message
1106
1102
Mobile Node (MN) (First Node)

Fig. 12

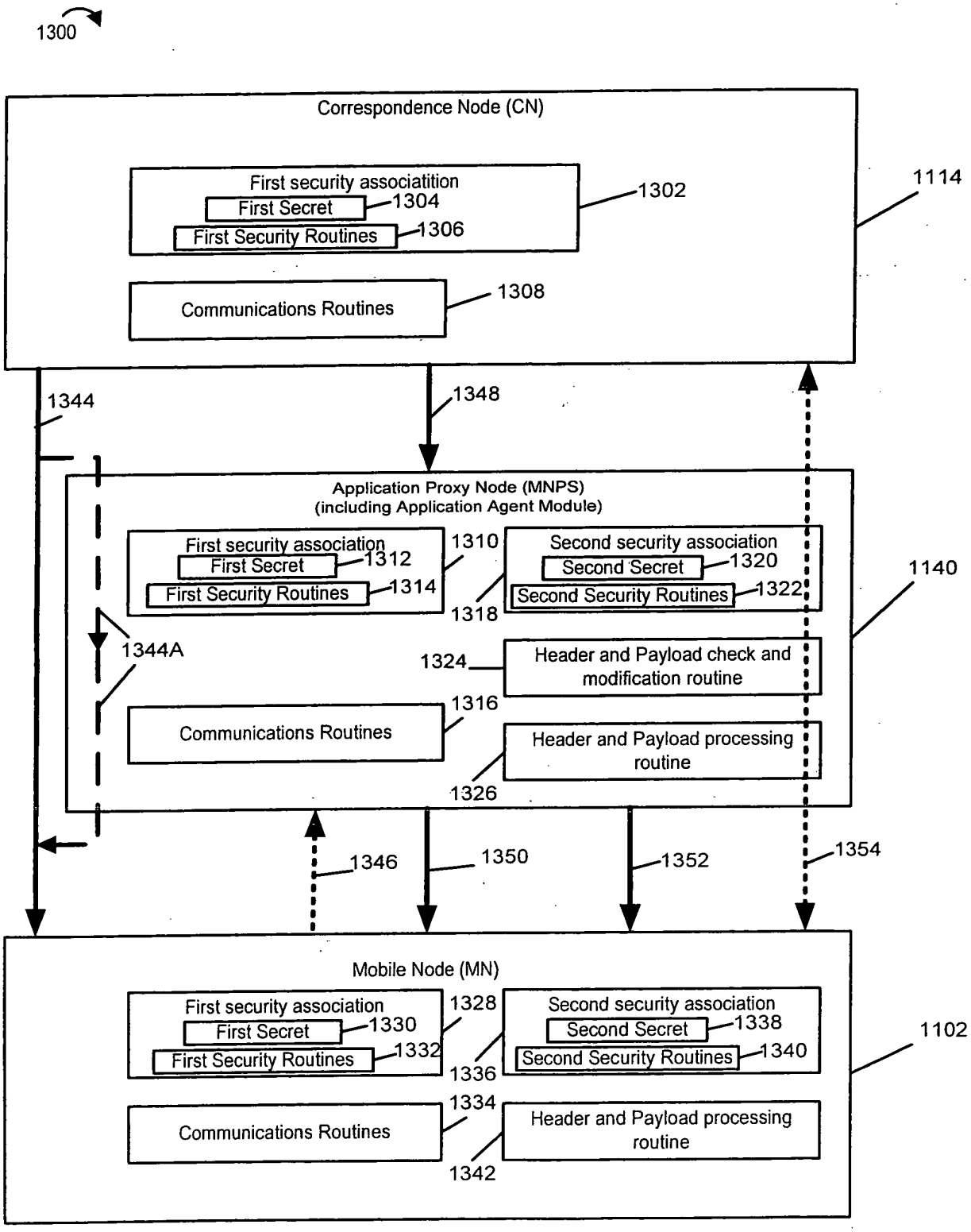

1300
Correspondence Node (CN)
First security associatition
First Secret
1304
First Security Routines
1306
1302
Communications Routines
1308
1114
1344
1348
Application Proxy Node (MNPS)
(including Application Agent Module)
First security association
First Secret
1312
First Security Routines
1314
1310
Second security association
Second Secret
1320
Second Security Routines
1322
1318
1140
1344A
1324
Header and Payload check and modification routine
Communications Routines
1316
Header and Payload processing routine
1326
1346
1350
1352
1354
Mobile Node (MN)
First security association
First Secret
1330
First Security Routines
1332
1328
Second security association
Second Secret
1338
Second Security Routines
1340
1336
1102
Communications Routines
1334
Header and Payload processing routine
1342

Fig. 13

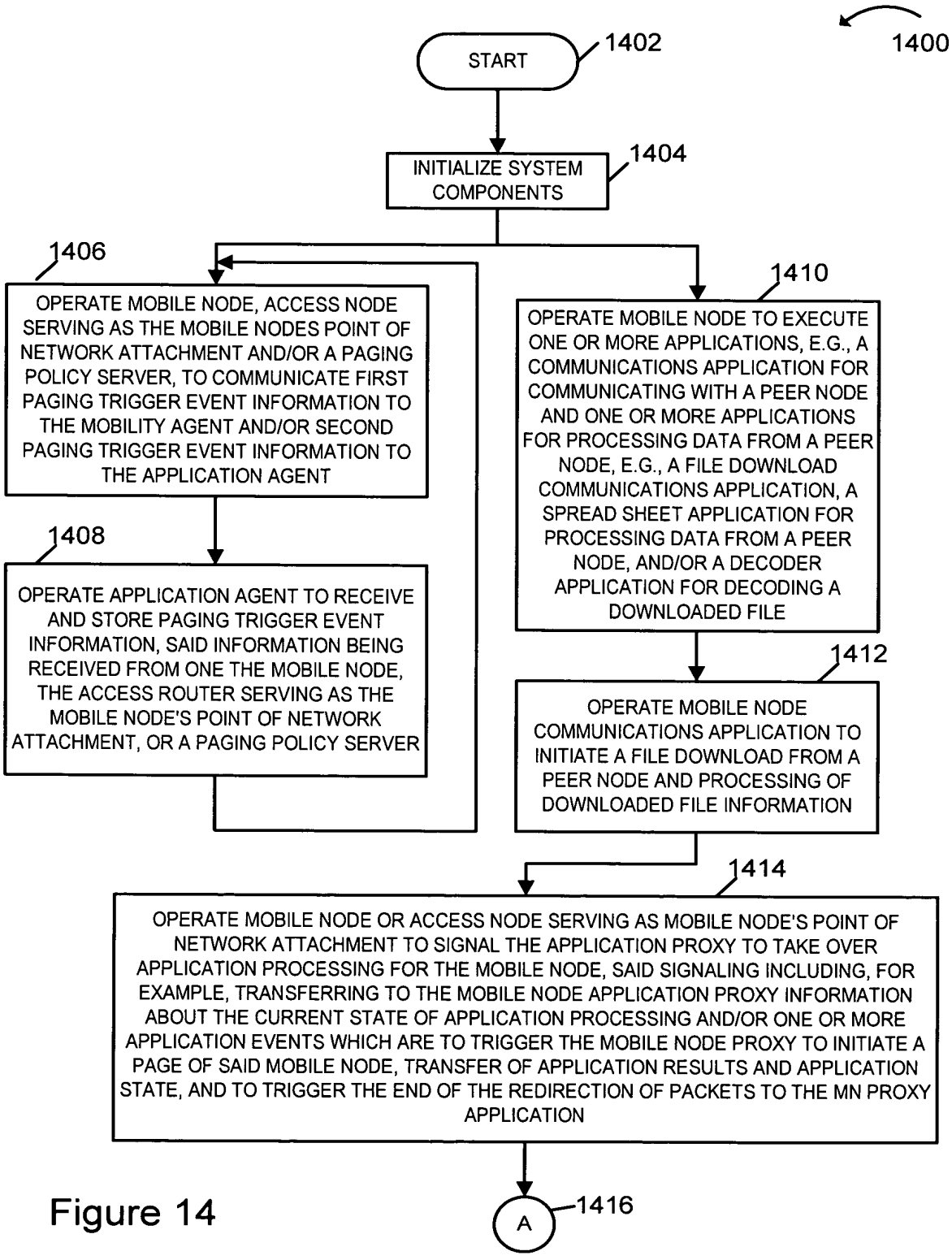

1400
START
1402
INITIALIZE SYSTEM COMPONENTS
1404
1406
OPERATE MOBILE NODE, ACCESS NODE SERVING AS THE MOBILE NODES POINT OF NETWORK ATTACHMENT AND/OR A PAGING POLICY SERVER, TO COMMUNICATE FIRST PAGING TRIGGER EVENT INFORMATION TO THE MOBILITY AGENT AND/OR SECOND PAGING TRIGGER EVENT INFORMATION TO THE APPLICATION AGENT
1408
OPERATE APPLICATION AGENT TO RECEIVE AND STORE PAGING TRIGGER EVENT INFORMATION, SAID INFORMATION BEING RECEIVED FROM ONE THE MOBILE NODE, THE ACCESS ROUTER SERVING AS THE MOBILE NODE'S POINT OF NETWORK ATTACHMENT, OR A PAGING POLICY SERVER
1410
OPERATE MOBILE NODE TO EXECUTE ONE OR MORE APPLICATIONS, E.G., A COMMUNICATIONS APPLICATION FOR COMMUNICATING WITH A PEER NODE AND ONE OR MORE APPLICATIONS FOR PROCESSING DATA FROM A PEER NODE, E.G., A FILE DOWNLOAD COMMUNICATIONS APPLICATION, A SPREAD SHEET APPLICATION FOR PROCESSING DATA FROM A PEER NODE, AND/OR A DECODER APPLICATION FOR DECODING A DOWNLOADED FILE
1412
OPERATE MOBILE NODE COMMUNICATIONS APPLICATION TO INITIATE A FILE DOWNLOAD FROM A PEER NODE AND PROCESSING OF DOWNLOADED FILE INFORMATION
1414
OPERATE MOBILE NODE OR ACCESS NODE SERVING AS MOBILE NODE'S POINT OF NETWORK ATTACHMENT TO SIGNAL THE APPLICATION PROXY TO TAKE OVER APPLICATION PROCESSING FOR THE MOBILE NODE, SAID SIGNALING INCLUDING, FOR EXAMPLE, TRANSFERRING TO THE MOBILE NODE APPLICATION PROXY INFORMATION ABOUT THE CURRENT STATE OF APPLICATION PROCESSING AND/OR ONE OR MORE APPLICATION EVENTS WHICH ARE TO TRIGGER THE MOBILE NODE PROXY TO INITIATE A PAGE OF SAID MOBILE NODE, TRANSFER OF APPLICATION RESULTS AND APPLICATION STATE, AND TO TRIGGER THE END OF THE REDIRECTION OF PACKETS TO THE MN PROXY APPLICATION
A
1416

Figure 14

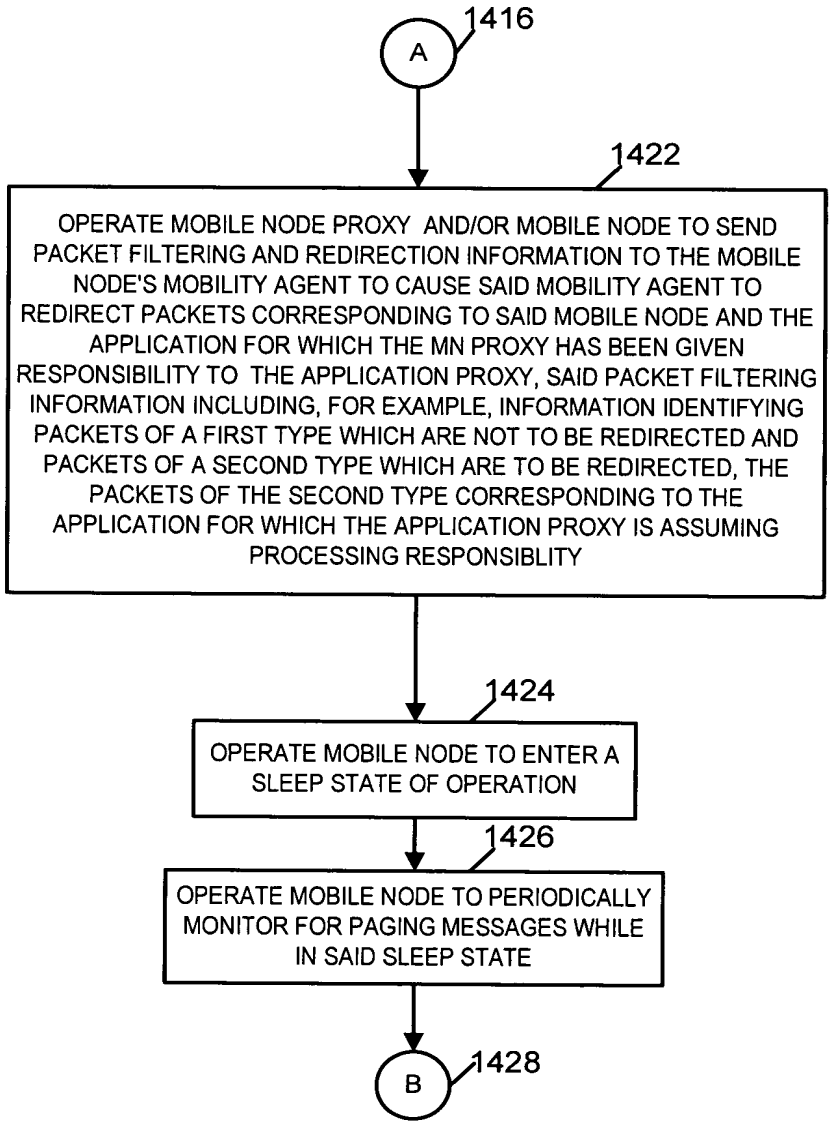

1416
A
1422
OPERATE MOBILE NODE PROXY AND/OR MOBILE NODE TO SEND PACKET FILTERING AND REDIRECTION INFORMATION TO THE MOBILE NODE'S MOBILITY AGENT TO CAUSE SAID MOBILITY AGENT TO REDIRECT PACKETS CORRESPONDING TO SAID MOBILE NODE AND THE APPLICATION FOR WHICH THE MN PROXY HAS BEEN GIVEN RESPONSIBILITY TO THE APPLICATION PROXY, SAID PACKET FILTERING INFORMATION INCLUDING, FOR EXAMPLE, INFORMATION IDENTIFYING PACKETS OF A FIRST TYPE WHICH ARE NOT TO BE REDIRECTED AND PACKETS OF A SECOND TYPE WHICH ARE TO BE REDIRECTED, THE PACKETS OF THE SECOND TYPE CORRESPONDING TO THE APPLICATION FOR WHICH THE APPLICATION PROXY IS ASSUMING PROCESSING RESPONSIBLITY
1424
OPERATE MOBILE NODE TO ENTER A SLEEP STATE OF OPERATION
1426
OPERATE MOBILE NODE TO PERIODICALLY MONITOR FOR PAGING MESSAGES WHILE IN SAID SLEEP STATE
B
1428

Figure 15

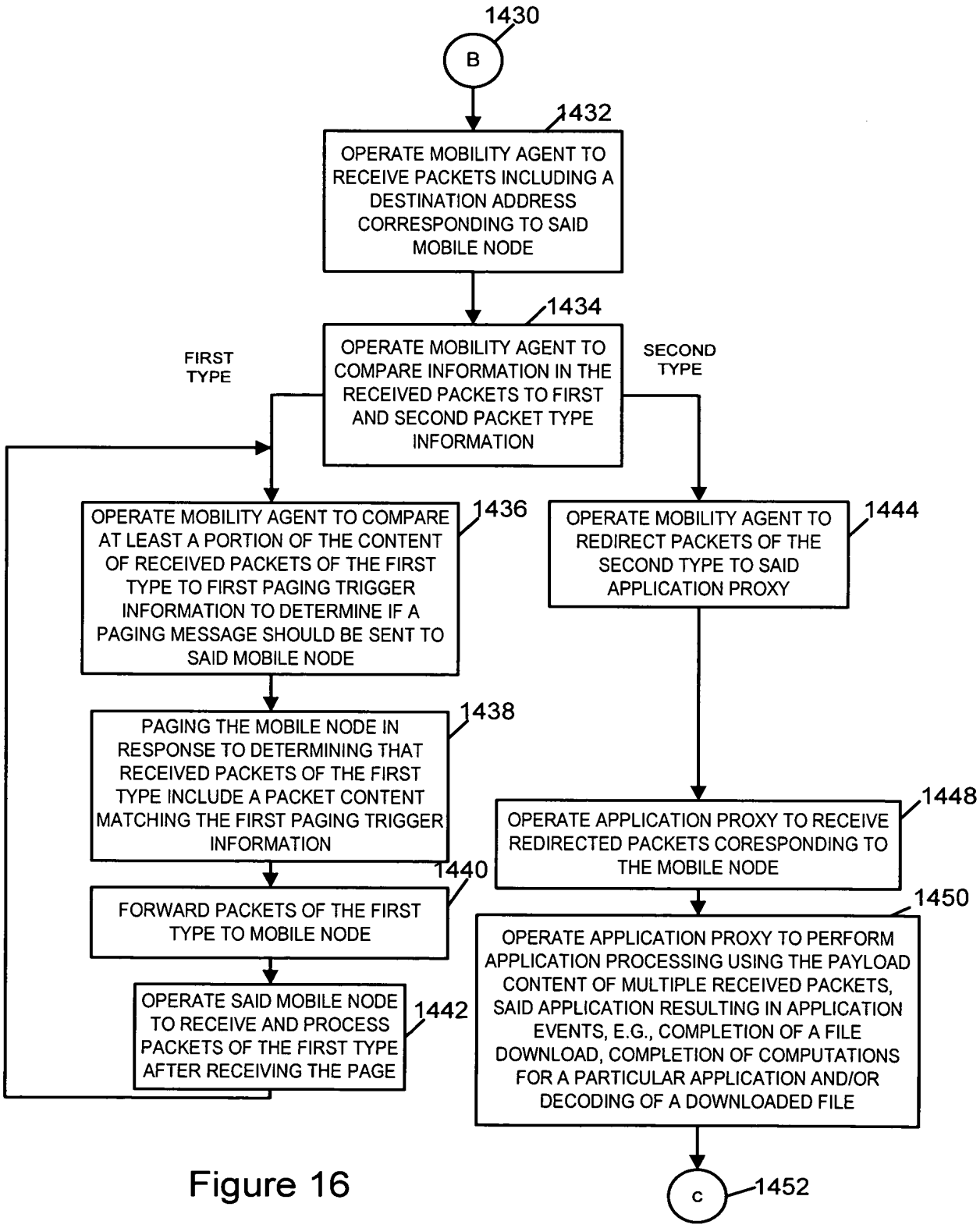
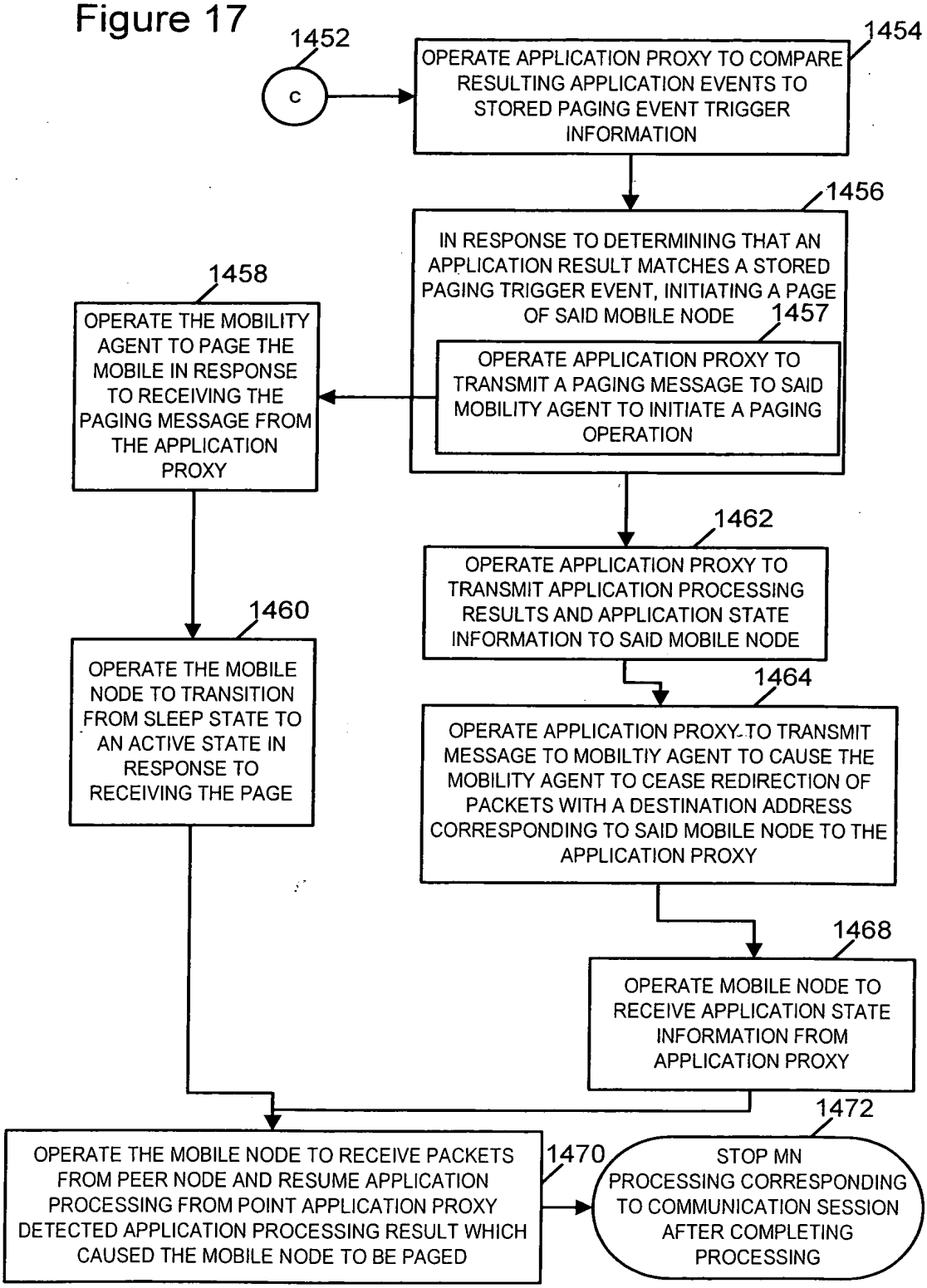

1430
B
1432
OPERATE MOBILITY AGENT TO RECEIVE PACKETS INCLUDING A DESTINATION ADDRESS CORRESPONDING TO SAID MOBILE NODE
1434
OPERATE MOBILITY AGENT TO COMPARE INFORMATION IN THE RECEIVED PACKETS TO FIRST AND SECOND PACKET TYPE INFORMATION
FIRST TYPE
SECOND TYPE
OPERATE MOBILITY AGENT TO COMPARE AT LEAST A PORTION OF THE CONTENT OF RECEIVED PACKETS OF THE FIRST TYPE TO FIRST PAGING TRIGGER INFORMATION TO DETERMINE IF A PAGING MESSAGE SHOULD BE SENT TO SAID MOBILE NODE
1436
OPERATE MOBILITY AGENT TO REDIRECT PACKETS OF THE SECOND TYPE TO SAID APPLICATION PROXY
1444
PAGING THE MOBILE NODE IN RESPONSE TO DETERMINING THAT RECEIVED PACKETS OF THE FIRST TYPE INCLUDE A PACKET CONTENT MATCHING THE FIRST PAGING TRIGGER INFORMATION
1438
OPERATE APPLICATION PROXY TO RECEIVE REDIRECTED PACKETS CORESPONDING TO THE MOBILE NODE
1448
FORWARD PACKETS OF THE FIRST TYPE TO MOBILE NODE
1440
OPERATE APPLICATION PROXY TO PERFORM APPLICATION PROCESSING USING THE PAYLOAD CONTENT OF MULTIPLE RECEIVED PACKETS, SAID APPLICATION RESULTING IN APPLICATION EVENTS, E.G., COMPLETION OF A FILE DOWNLOAD, COMPLETION OF COMPUTATIONS FOR A PARTICULAR APPLICATION AND/OR DECODING OF A DOWNLOADED FILE
1450
OPERATE SAID MOBILE NODE TO RECEIVE AND PROCESS PACKETS OF THE FIRST TYPE AFTER RECEIVING THE PAGE
1442
C
1452

Figure 16

Figure 17


1452
C
1454
OPERATE APPLICATION PROXY TO COMPARE RESULTING APPLICATION EVENTS TO STORED PAGING EVENT TRIGGER INFORMATION
1456
IN RESPONSE TO DETERMINING THAT AN APPLICATION RESULT MATCHES A STORED PAGING TRIGGER EVENT, INITIATING A PAGE OF SAID MOBILE NODE
1457
OPERATE APPLICATION PROXY TO TRANSMIT A PAGING MESSAGE TO SAID MOBILITY AGENT TO INITIATE A PAGING OPERATION
1458
OPERATE THE MOBILITY AGENT TO PAGE THE MOBILE IN RESPONSE TO RECEIVING THE PAGING MESSAGE FROM THE APPLICATION PROXY
1462
OPERATE APPLICATION PROXY TO TRANSMIT APPLICATION PROCESSING RESULTS AND APPLICATION STATE INFORMATION TO SAID MOBILE NODE
1460
OPERATE THE MOBILE NODE TO TRANSITION FROM SLEEP STATE TO AN ACTIVE STATE IN RESPONSE TO RECEIVING THE PAGE
1464
OPERATE APPLICATION PROXY TO TRANSMIT MESSAGE TO MOBILTIY AGENT TO CAUSE THE MOBILITY AGENT TO CEASE REDIRECTION OF PACKETS WITH A DESTINATION ADDRESS CORRESPONDING TO SAID MOBILE NODE TO THE APPLICATION PROXY
1468
OPERATE MOBILE NODE TO RECEIVE APPLICATION STATE INFORMATION FROM APPLICATION PROXY
1472
STOP MN PROCESSING CORRESPONDING TO COMMUNICATION SESSION AFTER COMPLETING PROCESSING
1470
OPERATE THE MOBILE NODE TO RECEIVE PACKETS FROM PEER NODE AND RESUME APPLICATION PROCESSING FROM POINT APPLICATION PROXY DETECTED APPLICATION PROCESSING RESULT WHICH CAUSED THE MOBILE NODE TO BE PAGED

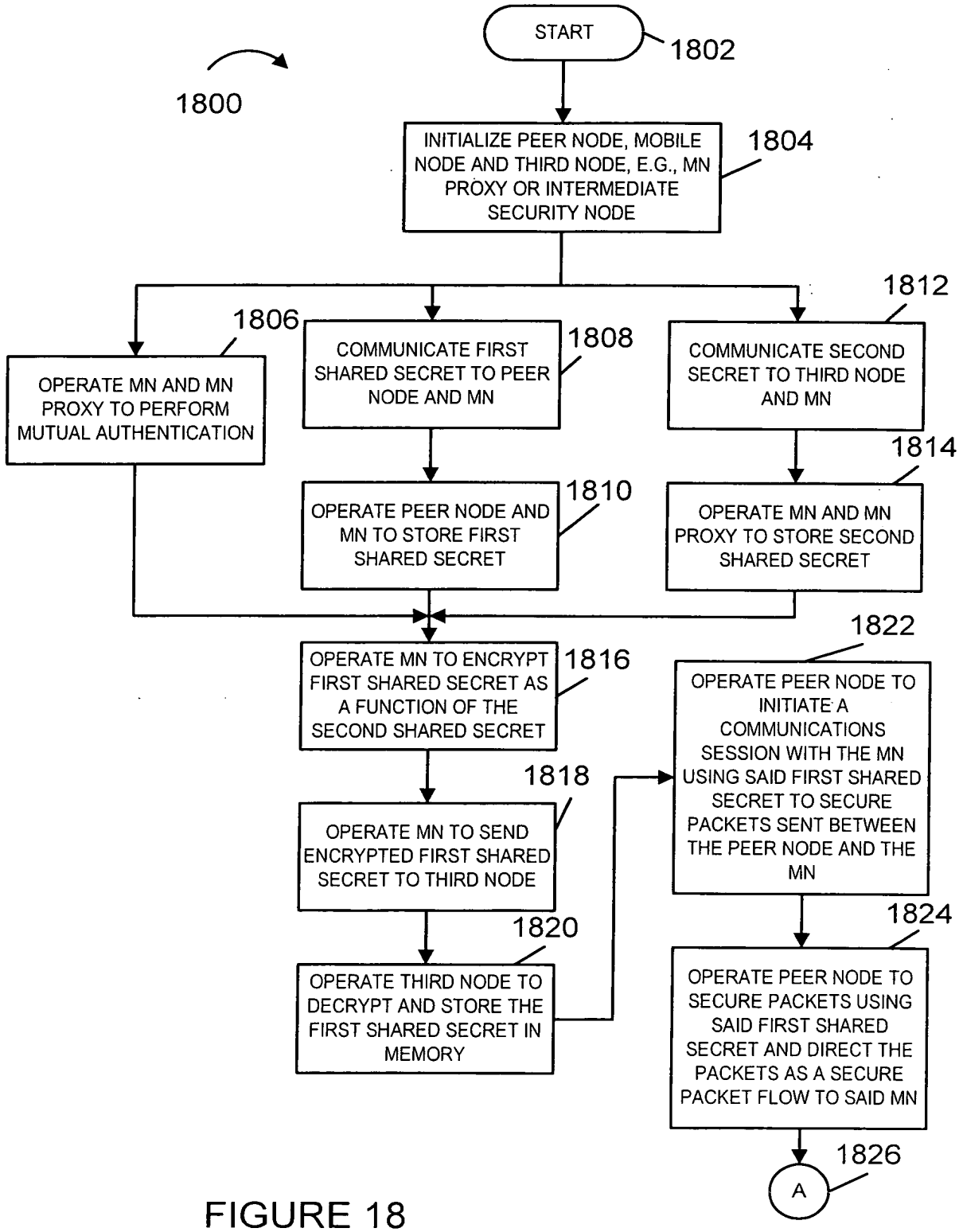
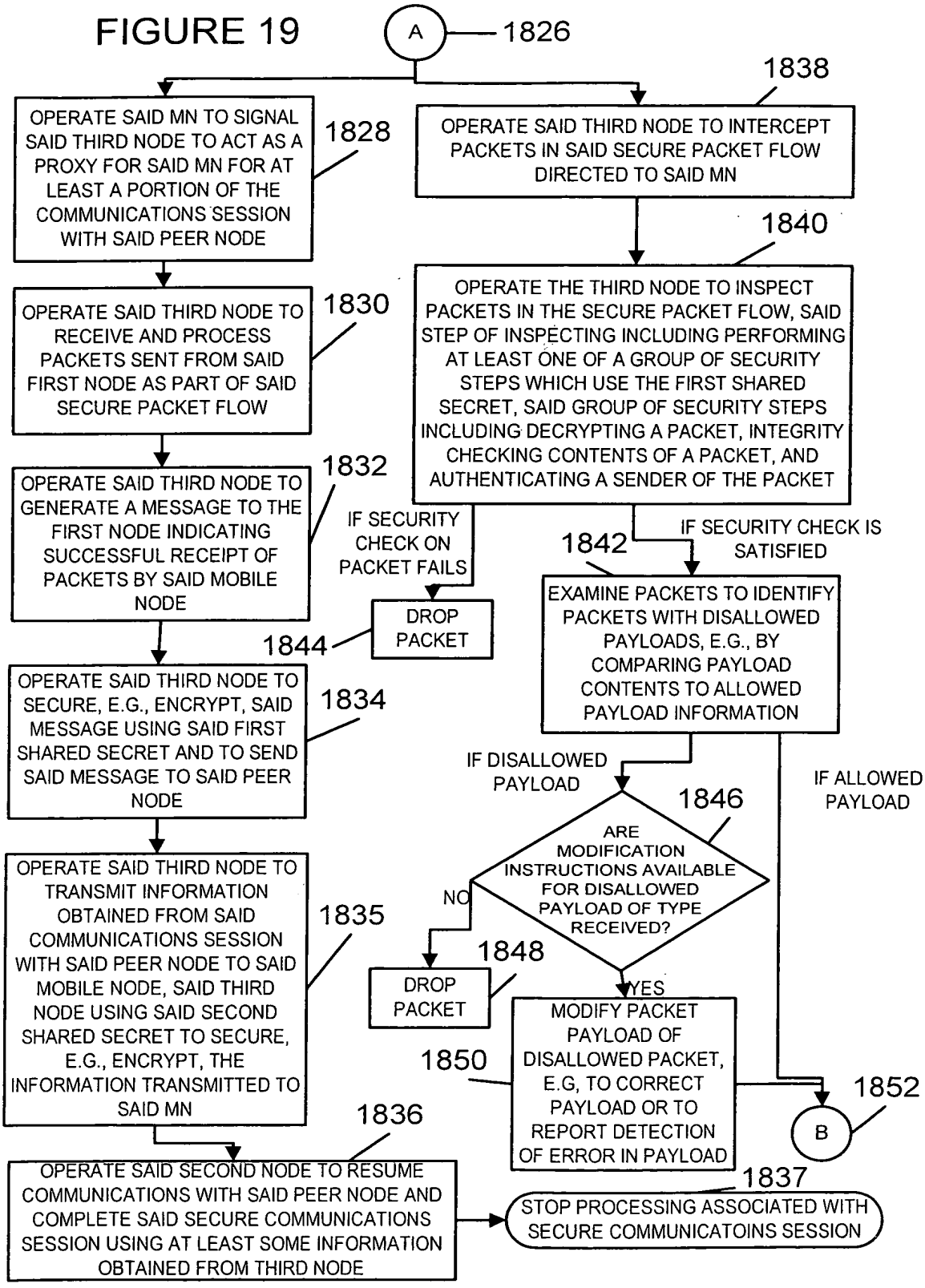

1800
START
1802
INITIALIZE PEER NODE, MOBILE NODE AND THIRD NODE, E.G., MN PROXY OR INTERMEDIATE SECURITY NODE
1804
1806
OPERATE MN AND MN PROXY TO PERFORM MUTUAL AUTHENTICATION
COMMUNICATE FIRST SHARED SECRET TO PEER NODE AND MN
1808
1812
COMMUNICATE SECOND SECRET TO THIRD NODE AND MN
OPERATE PEER NODE AND MN TO STORE FIRST SHARED SECRET
1810
1814
OPERATE MN AND MN PROXY TO STORE SECOND SHARED SECRET
OPERATE MN TO ENCRYPT FIRST SHARED SECRET AS A FUNCTION OF THE SECOND SHARED SECRET
1816
1822
OPERATE PEER NODE TO INITIATE A COMMUNICATIONS SESSION WITH THE MN USING SAID FIRST SHARED SECRET TO SECURE PACKETS SENT BETWEEN THE PEER NODE AND THE MN
1818
OPERATE MN TO SEND ENCRYPTED FIRST SHARED SECRET TO THIRD NODE
1820
1824
OPERATE THIRD NODE TO DECRYPT AND STORE THE FIRST SHARED SECRET IN MEMORY
OPERATE PEER NODE TO SECURE PACKETS USING SAID FIRST SHARED SECRET AND DIRECT THE PACKETS AS A SECURE PACKET FLOW TO SAID MN
1826
A

FIGURE 18

FIGURE 19


A
1826
1838
OPERATE SAID MN TO SIGNAL SAID THIRD NODE TO ACT AS A PROXY FOR SAID MN FOR AT LEAST A PORTION OF THE COMMUNICATIONS SESSION WITH SAID PEER NODE
1828
OPERATE SAID THIRD NODE TO INTERCEPT PACKETS IN SAID SECURE PACKET FLOW DIRECTED TO SAID MN
1840
OPERATE SAID THIRD NODE TO RECEIVE AND PROCESS PACKETS SENT FROM SAID FIRST NODE AS PART OF SAID SECURE PACKET FLOW
1830
OPERATE THE THIRD NODE TO INSPECT PACKETS IN THE SECURE PACKET FLOW, SAID STEP OF INSPECTING INCLUDING PERFORMING AT LEAST ONE OF A GROUP OF SECURITY STEPS WHICH USE THE FIRST SHARED SECRET, SAID GROUP OF SECURITY STEPS INCLUDING DECRYPTING A PACKET, INTEGRITY CHECKING CONTENTS OF A PACKET, AND AUTHENTICATING A SENDER OF THE PACKET
OPERATE SAID THIRD NODE TO GENERATE A MESSAGE TO THE FIRST NODE INDICATING SUCCESSFUL RECEIPT OF PACKETS BY SAID MOBILE NODE
1832
IF SECURITY CHECK ON PACKET FAILS
IF SECURITY CHECK IS SATISFIED
1842
DROP PACKET
1844
EXAMINE PACKETS TO IDENTIFY PACKETS WITH DISALLOWED PAYLOADS, E.G., BY COMPARING PAYLOAD CONTENTS TO ALLOWED PAYLOAD INFORMATION
OPERATE SAID THIRD NODE TO SECURE, E.G., ENCRYPT, SAID MESSAGE USING SAID FIRST SHARED SECRET AND TO SEND SAID MESSAGE TO SAID PEER NODE
1834
IF DISALLOWED PAYLOAD
IF ALLOWED PAYLOAD
1846
ARE MODIFICATION INSTRUCTIONS AVAILABLE FOR DISALLOWED PAYLOAD OF TYPE RECEIVED?
OPERATE SAID THIRD NODE TO TRANSMIT INFORMATION OBTAINED FROM SAID COMMUNICATIONS SESSION WITH SAID PEER NODE TO SAID MOBILE NODE, SAID THIRD NODE USING SAID SECOND SHARED SECRET TO SECURE, E.G., ENCRYPT, THE INFORMATION TRANSMITTED TO SAID MN
1835
NO
1848
DROP PACKET
YES
MODIFY PACKET PAYLOAD OF DISALLOWED PACKET, E.G, TO CORRECT PAYLOAD OR TO REPORT DETECTION OF ERROR IN PAYLOAD
1850
1852
B
1836
OPERATE SAID SECOND NODE TO RESUME COMMUNICATIONS WITH SAID PEER NODE AND COMPLETE SAID SECURE COMMUNICATIONS SESSION USING AT LEAST SOME INFORMATION OBTAINED FROM THIRD NODE
1837
STOP PROCESSING ASSOCIATED WITH SECURE COMMUNICATOINS SESSION

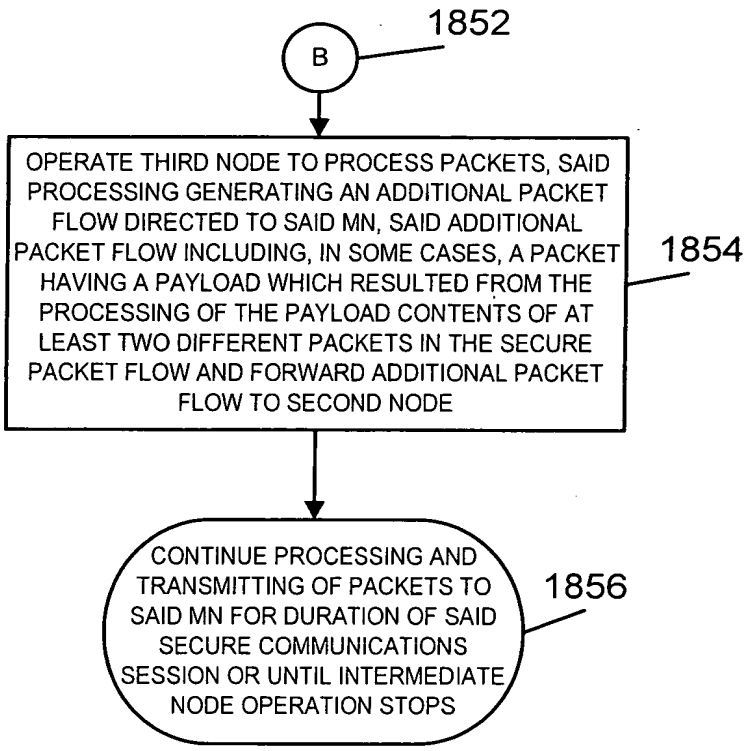

1852
B
OPERATE THIRD NODE TO PROCESS PACKETS, SAID PROCESSING GENERATING AN ADDITIONAL PACKET FLOW DIRECTED TO SAID MN, SAID ADDITIONAL PACKET FLOW INCLUDING, IN SOME CASES, A PACKET HAVING A PAYLOAD WHICH RESULTED FROM THE PROCESSING OF THE PAYLOAD CONTENTS OF AT LEAST TWO DIFFERENT PACKETS IN THE SECURE PACKET FLOW AND FORWARD ADDITIONAL PACKET FLOW TO SECOND NODE
1854
CONTINUE PROCESSING AND TRANSMITTING OF PACKETS TO SAID MN FOR DURATION OF SAID SECURE COMMUNICATIONS SESSION OR UNTIL INTERMEDIATE NODE OPERATION STOPS
1856

FIGURE 20